NATIONAL BUREAU OF STANDARDS REPORT

6251

PERFORMANCE TESTS OF TWO CLEANABLE IMPINGEMENT AIR FILTERS
VORTOX TYPES VN1 AND VN2

MANUFACTURED BY
VORTOX COMPANY
CLAREMONT, CALIFORNIA

by

Carl W. Coblentz and Paul R. Achenbach

Report to
Bureau of Yards and Docks
Office of the Chief of Engineers
Headquarters, U. S. Air Force
Washington, D. C.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
1000-12-4801

NBS REPORT
6251

December 23, 1958

PERFORMANCE TESTS OF TWO CLEANABLE IMPINGEMENT AIR FILTERS
VORTOX TYPES VN1 AND VN2

MANUFACTURED BY
VORTOX COMPANY
CLAREMONT, CALIFORNIA

by

Carl W. Coblentz and Paul R. Achenbach
Air Conditioning, Heating and Refrigeration Section
Building Technology Division

to

Bureau of Yards and Docks
Office of the Chief of Engineers
Headquarters, U. S. Air Force
Washington, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

PERFORMANCE TESTS OF TWO CLEANABLE IMPINGEMENT AIR FILTERS TYPE VN1 AND VN2

MANUFACTURED BY
VORTOX COMPANY
CLAREMONT, CALIFORNIA

by

Carl W. Coblentz and Paul R. Achenbach

1. Introduction

The performance characteristics of two cleanable viscous impingement air filters were determined to provide information for evaluating the relative economy of cleanable versus throw-away types of filters. This investigation was requested by the Defense Department through the Tri-Service program of research and development at the National Bureau of Standards to obtain the required data for the preparation of new air filter specifications.

The test results presented in this report were obtained on two new filters and include determination of the arrestance and pressure drop as related to the specific dust load for face velocities of 360 ft/min and 540 ft/min and information on the cleanability of the test specimens.

2. Description of Test Specimens

The two test specimens were of the cleanable viscous impingement type and were manufactured and supplied by the Vortox Company of Claremont, California. They were identified as their types VN1-20-20 and VN2-20-20. The measured outside dimensions of each filter were 19-1/2 in. square; the VN1 type was 1 in. thick and the VN2 type was 1-13/16 in. thick. Each had a net filter area of 18 in. square, i.e., 2.25 sq ft.

The filter media consisted of multitudinous helical coils of about 1/4 in. diameter and 1 in. long made of thin steel wire and placed at random between the steel frame and the face screens. The face screens consisted of two expanded steel sheets on the inlet or upstream side and a 16-mesh wire screen and an expanded steel sheet on the outlet or downstream side. The openings of the expanded steel sheets were diamond shaped.

The manufacturer also submitted his "Panel Filter Adhesive 9974" which was used for oiling the filter before each test.

3. Test Method and Procedure

The performance of the filters was determined at 360 ft/min and 540 ft/min face velocity, i.e., at an air flow rate of 810 cfm and 1215 cfm, respectively. The clean filters were immersed in the adhesive and left to dry in the laboratory at least 16 hours before being weighed and installed in the test apparatus. The initial pressure drop at each air velocity was measured and then the initial arrestance at the air veloctiy desired for that test was determined with the NBS "Dust Spot Method" as described in the paper, "A Test Method for Air Filters," by R. S. Dill (ASHVE Transactions, Vol. 44, p. 379, 1938).

The aerosol used for the arrestance determinations was Cottrell precipitate which had been sifted through a 100-mesh wire screen. In order to simulate actual operating conditions when loading the filters, four percent by weight of #7 cotton linters, previously ground in a Wiley mill with a four-millimeter screen, was fed simultaneously with the Cottrell precipitate. The pressure drop of the filters was recorded after each increment of 20 g of dust introduced into the apparatus. Whereas the arrestance measurements were made with 100 percent Cottrell precipitate, cotton linters were added to retain a ratio of four parts by weight to every 96 parts of Cottrell precipitate, including that amount used for the arrestance measurements. Arrestance determinations were made at the beginning and at the end of the loading period for each filter and at several intermediate load conditions. The filters were loaded with a dust concentration of approximately 1 g dust in 1000 cu ft of air until the pressure drop reached 0.5 in. W.G. in 360 ft/min face velocity tests and 0.8 in. W.G. in the tests with 540 ft/min face velocity.

After the filters had been loaded to capacity, they were cleaned with water and allowed to dry; then, oiled again as previously described, weighed and installed in the test apparatus for determining any change in pressure drop and in some cases for a new performance test.

4. Test Results

The data on pressure drop and arrestance observed during the tests for different dust loads are summarized in Tables 1 to 4 inclusive.

Table 1

Performance of Vortox Filter VN1(1 in. thick)
at 360 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.055	50*
46	0.095	51*
117	0.182	55*
157	0.335	59*
181	0.405	60*
199	0.480	63
204	0.515	--

* Average of 2 tests

Table 2

Performance of Vortox Filter VN1(1 in. thick)
at 540 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.125	56*
49	0.184	57*
121	0.325	59*
139	0.395	62*
166	0.470	62*
202	0.615	64*
229	0.805	66

* Average of 2 tests

Table 3

Performance of Vortox Filter VN2(1-13/16 in. thick)
at 360 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.070	52*
46	0.102	53*
114	0.165	55*
156	0.232	60
190	0.315	62
223	0.445	66
241	0.505	70

* Average of 2 tests

Table 4

Performance of Vortox Filter VN2(1-13/16 in. thick)
at 540 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.170	64*
49	0.243	70
85	0.301	76*
166	0.475	78
202	0.610	77
238	0.745	75
262	0.850	--

* Average of 2 tests

The preceding tables show the arrestance values and the pressure drop as a function of the dust load per square foot net filter area at face velocities of 360 ft/min and 540 ft/min.

The dust load per square foot net face area is the weight of lint and dust introduced into the test apparatus minus the fall-out in the upstream portion of the duct and divided by the net face area of the filters.

Fig 1 and 2 present these same values graphically using smooth curves to approximately fit the individual points of observation.

The arrestance increased generally with increasing dust loads, but the rate of increase varied among the two filters and also with the face velocity. The change in arrestance while loading the specimens ranged from 10 to 18 percent. However, at 540 ft/min face velocity, the 1-13/16 in. thick filter VN2, showed a rise in arrestance from 68 to 78 percent at 2/3 of its load and, then a drop of 75 percent by the time the filter was loaded to its maximum pressure drop.

The dust loads indicated by these graphs at 0.5 in. W.G. pressure drop for 360 ft/min face velocity and at 0.8 in. W.G. for 540 ft/min face velocity are shown in Table 5 as "Dust Holding Capacity". Also shown in this table are the mean arrestance values for each filter and each face velocity during the period in which the capacity dust load was being deposited. It will be noted that the dust holding capacity of the 1-13/16 in. thick filter is about 20 percent higher than for the 1-inch thick filter at 360 ft/min face velocity and only 10% higher at the 540 ft/min face velocity whereas the mean arrestance was only 3% higher at the low velocity but 13% higher at the high velocity operation for the thicker filter.

Table 5

Dust Holding Capacity and Mean Arrestance
(Determined from Fig 1 and 2)

Filter Type	VN1		VN2	
Face Velocity, ft/min	360	540	360	540
Final Pressure Drop, in. W.G.	0.5	0.8	0.5	0.8
Dust Holding Capacity, g/sq ft	202	227	240	250
Mean Arrestance, %	56	61	59	74

The weights of the oiled and drained filters and also the values of the pressure drop for both face velocities are shown in Table 6 for the new filters and after each cleaning cycle. This table indicates that the VN1 type retained about 40 g of the dirt collected in the first loading test without further accumulation of dirt when it was cleaned the second time. The type VN2(2 in. thick), however, increased its weight by almost 500 g after three loading operations with an increase in pressure drop of approximately 250%. The dust holding capacity during the third test, which is not reported here in detail, showed that the dust holding capacity was only about one half of that during the second run, both being run at the same face velocity. The cleaning of these filters had been performed with a stream of water at a temperature of about 150 F and was continued until the waste appeared clean.

Table 6

Cleanability of Filters

Filter Type and Condition	Weight of Filter grams	Pressure Drop, in. W.G. 360 ft/min	540 ft/min
VN1			
New	3032	0.055	0.116
After 1 loading and cleaning	3070	0.062	0.125
After 2 loadings and cleanings	3072	0.060	0.125
VN2			
New	3990	0.070	0.150
After 1 loading and cleaning	4080	0.080	0.170
After 2 loadings and cleanings	4375	0.150	0.305
After 3 loadings and cleanings	4486	0.180	0.372

VORTOX FILTER V N I

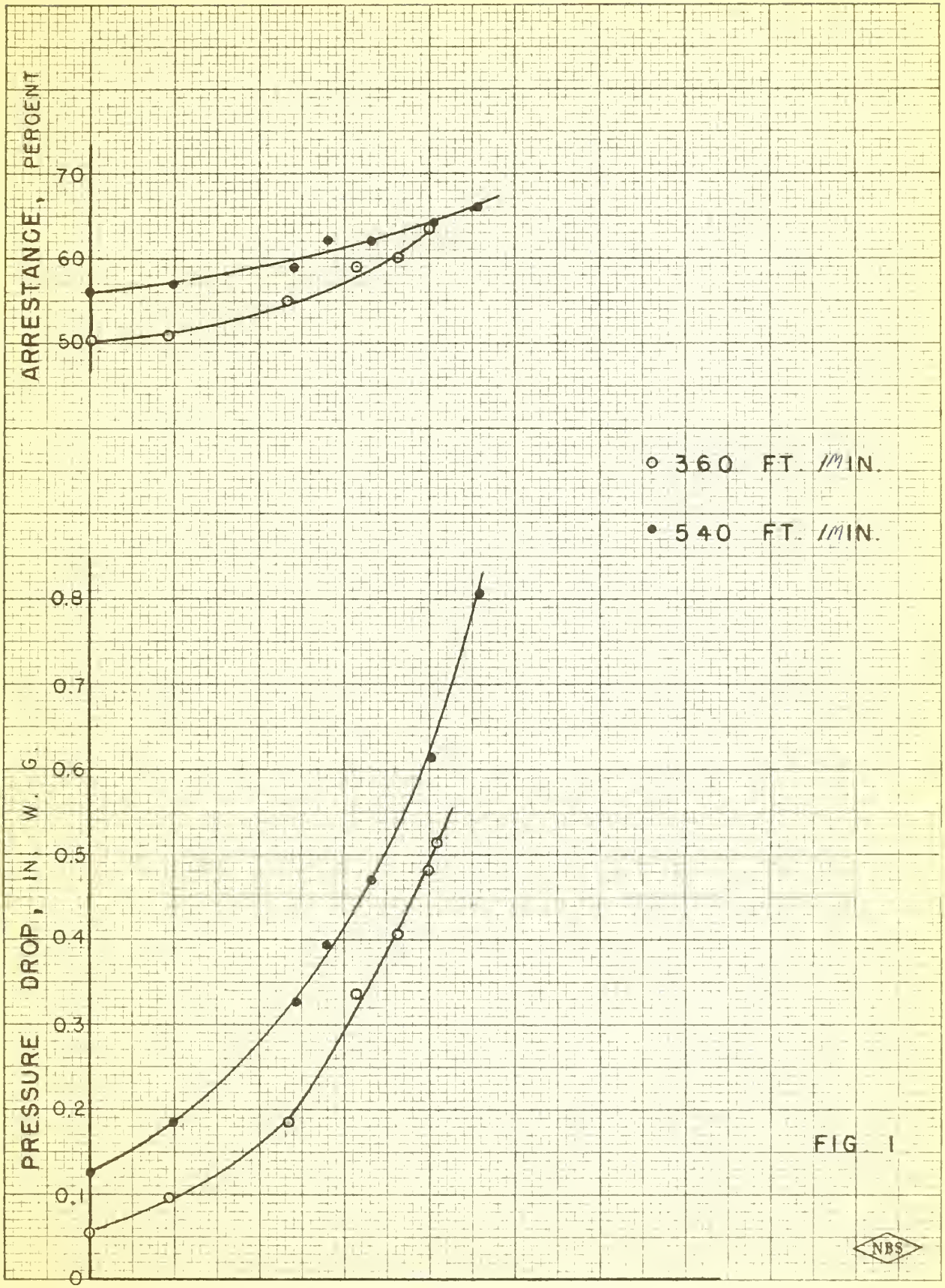

FIG. 1

NBS

VORTOX FILTER V N 2

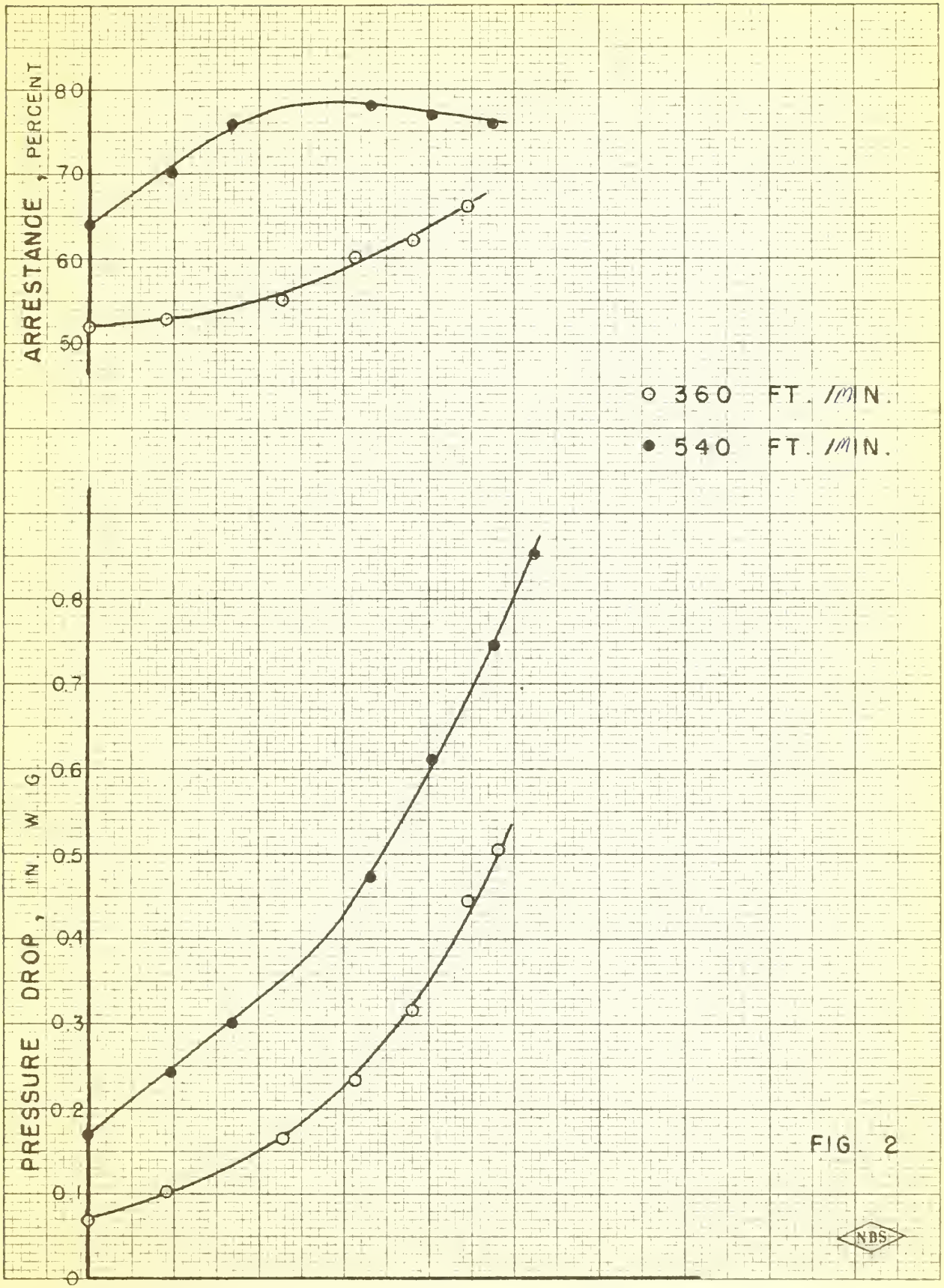

FIG. 2

NBS

U. S. DEPARTMENT OF COMMERCE

Lewis L. Strauss, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major laboratories in Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside front cover.

WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Anolog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Ionospheric Communication Systems.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio-Meteorology.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.


NBS